

souri Valley, and possibly from Oregon and British Columbia, eastward, over the lakes to Canada or New England; nine passed from the south-west, north and eastward, to the Middle or Eastern States; three passed from the south-west, eastward, to the South Atlantic States, and thence north-eastward; and two passed up north-eastward some distance off the Atlantic coast. Several of these storms divided into two portions, pursuing separate routes; and, with but one or two exceptions, they all increased in severity as they advanced eastward. The rainfall returns show a general deficiency on the Pacific coast; that, however, which was reported in the States east of the Rocky Mountains in March is probably compensated by the excess during January and February. During the entire three months the temperature has been colder than usual—at least for the country east of the Rocky Mountains.

WE have received the programme of the Leeds Naturalist's Field Club for the quarter April to June, from which we see that alternately with "exhibition of specimens and conversation," which takes place once a fortnight, papers on subjects of scientific interest are to be read. Excursions also take place on an average once a fortnight, the first object of the Club being "the minute investigation of the natural history, in all its branches, of the immediate neighbourhood of Leeds, and a more general investigation of the whole of the West Riding." This Society was founded in 1870, and was reorganised on a broader basis in March 1872, and seems to be doing good work.

A CORRESPONDENT writes, asking information with reference to the etymology of the word *aphis*.

THE following additions to the Brighton Aquarium have been made during the past week:—Picked Dogfish (*Acanthias vulgaris*), Larger Spotted Dog-fish (*Scyllium stellare*), Lesser do. (*Scyllium canicula*), Monkfish (*Rhina squatina*), Spotted Rays (*Raja maculata*), Sharp-nosed do. (*Raja lineta*), Streaked Gurnards (*Trigla lineata*), Grey Gurnards (*Trigla gurnardus*), Greater Weevers (*Trachinus draco*), Lesser do. (*Trachinus vipera*), Gemmeous Dragonets (*Callionymus lyra*), Lump Fish (*Cyclopterus lumpus*), Sea Snail (*Liparis vulgaris*), Yarrell's Blenny (*Blenniops ascani*), Sand Smelts (*Atherina presbyter*), Turbot (*Rhombus maximus*), Brill (*Rhombus lavis*), Sail Fluke (*Rhombus punctatus*), Plaice (*Pleuronectes platessa*), Flounders (*Pleuronectes flesus*), Soles (*Solea vulgaris*), Minnows (*Leuciscus phoxinus*), Tench (*Tinca vulgaris*), Masked Crab (*Corysides cassidellanus*), Tube Worms (*Serpula contortuplicata*), Sea Mice (*Aphrodite aculeata*), Sun Starfish (*Solaster papposa*), Mediterranean Corals (*Balanophyllia verrucari*), Golden Cup Coral (*Balanophyllia regia*), Devonshire Cup Coral (*Caryophyllia smithii*), Sea-fingers (*Alcyonium digitatum*), Sea-anemones (various).

THE additions to the Zoological Society's Gardens during the past week include an Indian leopard (*Felis pardus*), two Indian jackals (*Canis aureus*), presented by Capt. Henry; a Malabar Squirrel (*Sciurus maximus*), presented by Mr. White-side; three Egyptian cats *Felis chaus* (?) from Cashmere, presented by Capt. J. J. Bradshaw; two Egyptian geese (*Chenalopex aegyptiaca*), presented by Mr. H. W. Thornton; a hawk-finch (*Coccothraustes vulgaris*), from the British Isles, presented by the Viscountess Downe; four European Terrapins (*Emys lularia*) and a green lizard (*Lacerta viridis*, var. *chloronotus*), presented by Lord A. Russell; two black-handed spider monkeys (*Atles melanochir*); a white-throated Capuchin (*Cebus hypoleucus*); a blue-fronted Amazon (*Chrysotis aestiva*); a yellow-fronted Amazon (*C. ochrocephala*), and an orange-winged Amazon (*C. amazonica*), from Cartagena; a crested agouti (*Dasyprocta cristata*) from Colon; an alligator, and a red and yellow macaw (*Ara chloroptera*), from Barauquilla; a golden eagle (*Aquila chrysaetus*), purchased; a bladder-nosed seal (*Cystophora cristata*), from the North Atlantic, deposited.

ON THE HYPOTHESES WHICH LIE AT THE BASES OF GEOMETRY*

III.—Application to Space.

§ 1.—By means of these inquiries into the determination of the measure relations of an n -fold extent the conditions may be declared which are necessary and sufficient to determine the metric properties of space, if we assume the independence of line-length from position and expressibility of the line-element as the square root of a quadric differential, that is to say, flatness in the smallest parts.

First, they may be expressed thus: that the curvature at each point is zero in three surface-directions; and thence the metric properties of space are determined if the sum of the angles of a triangle is always equal to two right angles.

Secondly, if we assume with Euclid not merely an existence of lines independent of position, but of bodies also, it follows that the curvature is everywhere constant; and then the sum of the angles is determined in all triangles when it is known in one.

Thirdly, one might, instead of taking the length of lines to be independent of position and direction, assume also an independence of their length and direction from position. According to this conception changes or differences of position are complex magnitudes expressible in three independent units.

§ 2.—In the course of our previous inquiries, we first distinguished between the relations of extension or partition and the relations of measure, and found that with the same extensive properties, different measure-relations were conceivable; we then investigated the system of simple size-fixings by which the measure-relations of space are completely determined, and of which all propositions about them are a necessary consequence; it remains to discuss the question how, in what degree, and to what extent these assumptions are borne out by experience. In this respect there is a real distinction between mere extensive relations, and measure relations; in so far as in the former, where the possible cases form a discrete manifoldness, the declarations of experience are indeed not quite certain, but still not inaccurate; while in the latter, where the possible cases form a continuous manifoldness, every determination from experience remains always inaccurate: be the probability ever so great that it is nearly exact. This consideration becomes important in the extensions of these empirical determinations beyond the limits of observation to the infinitely great and infinitely small; since the latter may clearly become more inaccurate beyond the limits of observation, but not the former.

In the extension of space-construction to the infinitely great, we must distinguish between *unboundedness* and *infinite extent*, the former belongs to the extent relations, the latter to the measure-relations. That space is an unbounded three-fold manifoldness, is an assumption which is developed by every conception of the outer world; according to which every instant the region of real perception is completed and the possible positions of a sought object are constructed, and which by these applications is for ever confirming itself. The unboundedness of space possesses in this way a greater empirical certainty than any external experience. But its infinite extent by no means follows from this; on the other hand if we assume independence of bodies from position, and therefore ascribe to space constant curvature, it must necessarily be finite provided this curvature has ever so small a positive value. If we prolong all the geodesics starting in a given surface-element, we should obtain an unbounded surface of constant curvature, *i.e.*, a surface which in a flat manifoldness of three dimensions would take the form of a sphere, and consequently be finite.

§ 3. The questions about the infinitely great are for the interpretation of nature useless questions. But this is not the case with the questions about the infinitely small. It is upon the exactness with which we follow phenomena into the infinitely small that our knowledge of their causal relations essentially depends. The progress of recent centuries in the knowledge of mechanics depends almost entirely on the exactness of the construction which has become possible through the invention of the infinitesimal calculus, and through the simple principles discovered by Archimedes, Galileo, and Newton, and used by modern physics. But in the natural sciences which are still in want of simple principles for such constructions, we seek to discover the causal relations by following the phenomena into great minuteness, so far as the microscope permits. Questions

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about the measure-relations of space in the infinitely small are not therefore superfluous questions.

If we suppose that bodies exist independently of position, the curvature is everywhere constant, and it then results from astronomical measurements that it cannot be different from zero; or at any rate its reciprocal must be an area in comparison with which the range of our telescopes may be neglected. But if this independence of bodies from position does not exist, we cannot draw conclusions from metric relations of the great, to those of the infinitely small; in that case the curvature at each point may have an arbitrary value in three directions, provided that the total curvature of every measurable portion of space does not differ sensibly from zero. Still more complicated relations may exist if we no longer suppose the linear element expressible as the square root of a quadric differential. Now it seems that the empirical notions on which the metrical determinations of space are founded, the notion of a solid body and of a ray of light, cease to be valid for the infinitely small. We are therefore quite at liberty to suppose that the metric relations of space in the infinitely small do not conform to the hypotheses of geometry; and we ought in fact to suppose it, if we can thereby obtain a simpler explanation of phenomena.

The question of the validity of the hypotheses of geometry in the infinitely small is bound up with the question of the ground of the metric relations of space. In this last question, which we may still regard as belonging to the doctrine of space, is found the application of the remark made above; that in a discrete manifoldness, the ground of its metric relations is given in the notion of it, while in a continuous manifoldness, this ground must come from outside. Either therefore the reality which underlies space must form a discrete manifoldness, or we must seek the ground of its metric relations outside it, in binding forces which act upon it.

The answer to these questions can only be got by starting from the conception of phenomena which has hitherto been justified by experience, and which Newton assumed as a foundation, and by making in this conception the successive changes required by facts which it cannot explain. Researches starting from general notions, like the investigation we have just made, can only be useful in preventing this work from being hampered by too narrow views, and progress in knowledge of the interdependence of things from being checked by traditional prejudices.

This leads us into the domain of another science, of physics, into which the object of this work does not allow us to go to-day.

Synopsis

PLAN of the Inquiry:

- I. Notion of an n -ply extended magnitude.
 - § 1. Continuous and discrete manifoldnesses. Defined parts of a manifoldness are called Quanta. Division of the theory of continuous magnitude into the theories
 - (1) Of mere region-relations, in which an independence of magnitudes from position is not assumed;
 - (2) Of size-relations, in which such an independence must be assumed.
 - § 2. Construction of the notion of a one-fold, two-fold, n -fold extended magnitude.
 - § 3. Reduction of place-fixing in a given manifoldness to quantity-fixings. True character of an n -fold extended magnitude.
- II. Measure-relations of which a manifoldness of n dimensions is capable on the assumption that lines have a length independent of position, and consequently that every line may be measured by every other.
 - § 1. Expression for the line-element. Manifoldnesses to be called Flat in which the line-element is expressible as the square-root of a sum of squares of complete differentials.
 - § 2. Investigation of the manifoldness of n -dimensions in which the line-element may be represented as the square root of a quadric differential. Measure of its deviation from flatness (curvature) at a given point in a given surface-direction. For the determination of its measure-relations it is allowable and sufficient that the curvature be arbitrarily given at every point in $\frac{n-1}{2}$ surface directions.
 - § 3. Geometric illustration.
 - § 4. Flat manifoldnesses (in which the curvature is everywhere = 0) may be treated as a special case of manifoldnesses with constant curvature. These can also be defined

as admitting an independence of n -fold extents in them from position (possibility of motion without stretching).

§ 5. Surfaces with constant curvature.

III. Application to Space.

§ 1. System of facts which suffice to determine the measure-relations of space assumed in geometry.

§ 2. How far is the validity of these empirical determinations probable beyond the limits of observation towards the infinitely great?

§ 3. How far towards the infinitely small? Connection of this question with the interpretation of nature.

THE DEVELOPMENT THEORY IN GERMANY*

III.

Chorology: or, the Geographical Distribution of Living Beings

THE importance of the theory of Evolution does not consist in its accounting for this or that particular fact, but in its explaining all biological facts collectively. It is found to be confirmed in every detail by the mode of distribution of the various organisms on the surface of the earth. This distribution had already been studied by Alexander von Humboldt and Fr. Schouw for plants, by Berghaus and Schmarda for animals. But previous to Darwin and Wallace, this study had produced only a collection of unsystematised facts; Haeckel has attempted to create out of it a special science under the name of *Chorology*.

With the exception of the monocellular protozoa, which, on account of their simplicity, have been able to appear at the same time or at several times in different places; with the exception also of species which owe their origin to a hybrid or bastard generation, and which it has been possible to reproduce in different circumstances wherever the parent species have previously spread, it must be admitted that each of the other species has only been originated a single time and in a single place. But, once produced, they must, as a consequence of the struggle for existence, and in virtue of the laws of population, or rather of excess of population, tend to spread to the widest possible extent. Animals and plants migrate as well as man, both actively and passively.

In the case of animals, which have, more than plants, freedom of movement, active migration plays the principal part. The more easy locomotion is in the case of any species, the more rapidly is the species bound to spread. This is why birds and insects, furnished with wings, although referable to a less number of orders or natural groups than other animals, yet present a very great diversity of species slightly distinguishable from one another; this is to be ascribed to the fact that the facility with which they can move from place to place has subjected them to the modifying influences of the most varied localities. After birds and insects the swiftest runners among the denizens of the land, the best swimmers among the inhabitants of the water have been subject to the widest extension. With regard to animals which are fixed or immovable while being developed, corals, tubicolæ, tunicata, crinoids, &c., they usually enjoy during their youth so much of the power of movement as admits of their displacement. A great number of floating plants are also transported to great distances by water.

But the spread of a large number of plants and of certain animals can be explained only by a passive migration. The wind sweeps to great distances, sometimes over seas, eggs of small animals, seeds, and sometimes even minute organisms; this explains the well-known phenomena of showers of frogs. These eggs, these seeds, these small organisms, sometimes fall into the water, which transports them to still greater distances. Trunks of trees, which traverse the ocean under the direction of the currents, and those which the tempest hurls from the mountain tops, can carry with them, hidden in their interstices, in the moss or the parasitical plants with which they are covered, in the earth which adheres to their roots, innumerable germs to be developed in new regions. The icebergs of the polar sea have landed foxes and bears even on the shores of Iceland and Britain. Birds, insects, mammals which are removed, carry with them thousands of parasites, microscopic beings, eggs or germs. Man himself carries them about more abundantly still along with the varied materials he employs for his works and his industry.

The fact of the distribution of certain species which cannot be explained by migration, either active or passive, may be accounted for by geological facts. In consequence of the im-

* Continued from vol. vii. p. 434.